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VARIATION IN BEES—A REPLY TO MR. LUTZ.

EVERETT F. PHILLIPS.

In the December (1903) number of this journal there appeared an article entitled "Comparative Variability of Drones and Workers of the Honey Bee" by Dr. D. B. Casteel and myself in which we concluded that the drones show the more variability, which result we attributed to the effect of the size of the cells on the developing larvæ and pupæ. Mr. Frank E. Lutz in the April (1904) number of this BULLETIN thinks it "well worth while to consider a few points about the paper" and concludes that we have not proven our point. I desire here to point out the errors in his manner of dealing with our measurements and his methods of drawing conclusions and to defend our position.

The fact that in the consideration of abnormal veins we found that "there are 206 irregular drone wings and 30 irregular worker wings or almost seven times as many for drones as for workers" points rather conclusively to our position in regard to comparative variability. Our statements in regard to coloration are also disregarded, evidently because there were no figures given and therefore they were not considered worthy of mention. In another paper¹ I have dealt with the comparative constancy of the color areas of the two sexes and there offer evidence which confirms the position maintained in our paper, although as there used it was intended to prove an entirely different point. In quoting from a letter from Mr. E. R. Root, a high authority in apiculture, it was there stated: "The drones from these queens (imported Italians of pure stock) varied greatly in their markings. Some of their sons would have a great deal of yellow on them, while others would be quite dark. . . . *Bees* (workers) from these queens were all uniformly marked." In variation work but few investigators take the trouble to study more than one character yet here are two which are rather conclusive and on these we would be willing to rest the case.

¹ "A Review of Parthenogenesis," *Proc. Am. Philos. Soc.*, XLII., No. 174; *vide* pp. 277-8.

I will now take up the more definite criticisms of Mr. Lutz. In our paper we gave reasons which to us seemed good why we did not employ the standard deviation method in our work, stating distinctly that "that would be undesirable except with far more measurements"; this could be interpreted only as a desire on our part to avoid a high probable error and no one need "wonder greatly" why we did not employ this simple test since we distinctly stated that we did not think it desirable, giving full reasons for such a decision. It was not our intention to take exception to the methods of the workers in variation for I believe that the results of variation work should be stated in mathematical formulæ where such a thing is possible without too great a "probable error." If our critic is trying to defend such methods under the impression that we combat them, he is laboring under a misapprehension. However Mr. Lutz has seen fit to figure out the standard deviation and probable error for two of our tables and concludes "that the differences between the two sexes, as shown by these data are of no significance." I am still of the opinion that it is unwise to use these methods for so few individuals on account of the large probable error but since this is the way in which our results are questioned let us examine the figures and see if there is not "great danger that, having collected a set of measurements" our critic makes "a show of accuracy that will lead" him "and others astray by reason of careless and insufficient analysis." For ease of reference I give the results of Mr. Lutz.

The argument of Mr. Lutz is that since there is as much difference in standard deviation between various lots of drones as there is between the averages of the standard deviations of drones and workers, our conclusion that drones vary the more is false. But is it not evident that in every case of the drones (except lot II.) the standard deviation or index of variability is greater than that of the workers? I cannot see what bearing the differences in the standard deviation of the various lots of drones has on the question since in every case except one, the drones do vary more than the workers; and this it was that we attempted to prove. In regard to this lot II. we said: "The drones in lot II. were taken from a hive in which there were no drone cells except

HOOKS ON HIND WING.

| Drones. | | | |
|----------|----------------------|---------------------|------------------------------|
| Lot. | Number of Specimens. | Standard Deviation. | Probable Error. ¹ |
| I. | 50 | 2.1548 | 0.1453 |
| II. | 100 | 1.5435 | 0.0736 |
| III. | 100 | 1.7716 | 0.0845 |
| IV. | 100 | 1.6486 | 0.0786 |
| V. | 50 | 2.0988 | 0.1416 |
| VI. | 98 | 1.9377 | 0.0934 |
| Workers. | | | |
| I. | 50 | 1.5223 | 0.1027 |
| II. | 350 | 1.5564 | 0.0397 |
| III. | 100 | 1.5523 | 0.0740 |

VEIN R.

| Drones. | | | |
|----------|----------------------|---------------------|-----------------|
| Lot. | Number of Specimens. | Standard Deviation. | Probable Error. |
| I. | 50 | 2.4023 | 0.1620 |
| III. | 100 | 2.9598 | 0.1412 |
| V. | 50 | 2.2517 | 0.1519 |
| Workers. | | | |
| I. | 50 | 1.5637 | 0.1055 |

possibly a very few in the corners of the frame or near the top bar of the frame since all the combs were made on what bee-keepers call foundation and the cells were uniformly of worker size. These drones show the least variation since they were all hatched under the same conditions." Even if we add the probable error to the standard deviation of workers and subtract it from that of the drones this result holds except in lots II. and IV. and it would seem that from these figures (made by Mr. Lutz himself) that our results are most strongly confirmed.

The additional criticism is made that we lumped the different lots together because they seemed to be alike "when really their only claim to homogeneity is that they are of the same sex and all bees — Italians, hybrids, 'peculiar strains,' et al., from central Ohio to eastern Pennsylvania being jumbled together." This

¹ In discussing the average standard deviation of this table Mr. Lutz takes the average of the probable error for the lots of 50 and 100 without taking into consideration that the probable error should be smaller for 500 than for these lots. Surely since all the lots show the same greater variability of the drones (except lot II. as explained later) the probable error is considerably smaller than that given by Mr. Lutz.

was done only in the case of our figures concerning the ratios between the veins M_2 and m where a careful examination showed us that these ratios did not vary according to lots but from the criticism it might be inferred that we had committed this "grave error" throughout the work. Just how Mr. Lutz could know, since the ratios for the individual wings were not published, that we had "jumbled together" some measurements in an unjustifiable manner is still a mystery but I am convinced that his criticism is unjust, having carefully examined the ratios with this very criticism in mind at the time of the preparation of our paper.

At the close of his article our critic says: "It is also probably unnecessary to remark that, even if it turns out that the greater variability of the drones can be established, their proof of their theory to account for this difference seem rather unsatisfactory." I think it is shown, by us and by Mr. Lutz, that the drones do vary the more and our theory of the cause, based as it is on careful investigations of the habits of the bee, must be controverted by more observations of an equally careful nature. Too often students of variation work on forms, concerning the habits of which they know nothing, and conclusions are reached which would be modified if causes were looked for in the habits, but I feel free to state that we are not open to that criticism.

By omitting the parts of our paper in which we explain our stand regarding the variability being "due to chance," Mr. Lutz would make out that we do not know that all chance is in accord with some mathematical formula. On this point we stated: "It may be argued that variation according to chance is but a way of stating our ignorance of the true law, but if there is a law for this variation it is certainly very obscure, and the working out of this law would require an extremely large number of measurements taken from individuals each one with its life history known," and again: "While it is probable that even this chance is according to fixed law, the fact remains that in any event this law is beyond a possibility of formulation from any observations except those extending over far more individuals than those here used." If as we believe the particular size variation of any individual bee depends on the size of the cell in which it grows, then the formulation of this law of variation must be

based on the law which governs the queen in moving over the comb and in choosing where she shall lay her eggs and on the law which governs the bees in cell building. We leave it to our critic to formulate these laws since we confess to a lack of mathematical ability for any such problems.

Finally we acknowledge the mistake in averages mentioned by Mr. Lutz but can only state that we believe this to be the only correct criticism of our paper which he has made.

ZOÖLOGICAL LABORATORY,
UNIVERSITY OF PENNSYLVANIA.